sun and with increase in cloudiness. In the first place under the more simple conditions presented by a clear sky, one of the prime objects of sky actinometry ought to be to fix the relation between the radiation from the sky on the one hand and the height of the sun and diffusing power of the atmosphere on the other. Here a comparison between the observations and the theory of L.V. King may be of value, and may lead to a conception of the ratio between the amount of radiant energy diffused by the dust particles and the amount transformed by them into heat. A close agreement between observations and the theory named is not to be expected without an extension of the theory or an adjustment of the observations, while the reflection of the light from the earth's surface introduces a complication not considered in the theory. This is probably the reason why Aldrich,[1] observing in California, found a more rapid decrease in the sky radiation than demanded by the theory.

From the climatological point of view the influence of clouds upon the heat exchange is naturally of great importance, though very difficult to subject to general rules. The cloud-forms are innumerable and the influence of different clouds exhibits great variations. From my observations at Upsala, with the instrument described above in the summer of 1918, and at Washington in the summer of 1919, I have drawn up the following table, wherein the numbers ought only to be taken to be what they are—the average of some few cases.

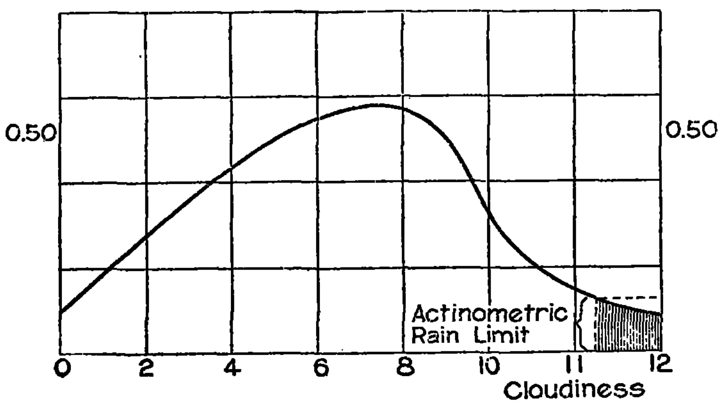

FIG. 1.—Variation in sky radiation with cloudiness.

TABLE 1.—*Variation in sky radiation with cloudiness.*

(Sun's zenith distance 10°-30°.)

	R. gr. cal. cm². min.	$\frac{dR}{dn}$
(1) Radiation from clear sky:		
(a) Transmission for sun radiation about 0.75	0.10	+
(b) Transmission for sun radiation about 0.50	0.30	+
(2) Sky covered by Ci-St	0.15-0.30	+
(3) Sky covered by A-St	0.20-0.40	+
(4) Sky covered by St-Cu (not very dense), about	0.50	±
(5) Sky covered by Nb (not very dense), about	0.35	−
(6) Sky covered by Nb (very dense)	0.10	−

The table shows some interesting and important features. With increasing density [n=nebulosity] of the cloud sheet the radiation from the sky first increases in order to reach a maximum, after which it decreases with increased heaviness of the cloud. For the cloudiness corresponding to the maximum of sky radiation, the sun radiation is practically nil. The radiation income corresponding to the cloudiness 10 is consequently under these conditions not equal to 0, as is often assumed, but about 50 per cent of the sun radiation when the sky is clear. On the average the cloudiness 10 causes a decrease in the total heat income down to about 30 per cent. In regard to the influence of cloudiness upon the total heat income, I have given a survey of the question, just published in the *Meteorologische Zeitschrift*,[3] on the basis of Kimball's observations with the Callendar recording-instrument. A more detailed treatment of the question will soon appear by Prof. Kimball himself.[4] The superposition of the diffused sky radiation upon the direct radiation from the sun is, in large part, the reason that the heat income at the cloudiness 5 (or 50 per cent) is nearly 80 per cent of the heat income for clear sky.

After the maximum is reached an increased cloudiness causes a decrease in the radiation from the sky. When the radiation from the sky has reached a certain low value—not very different from the value corresponding to a clear sky—rain generally begins to fall. This actinometric rain limit is naturally dependent upon the height of the sun above the horizon, but seems, for uniformly clouded sky and constant solar height, to maintain a value that fluctuates only between narrow limits. For the local forecasting of rain a closer investigation of these conditions may prove to be of value.

Purely physical and mathematical problems may be solved by one single investigator limited to a certain place and, in regard to time, dependent only upon the rapidity of the work of the investigator's brain or his experimental speed and skill. But meteorological problems need for their solution many observers distributed over wide areas and continuing their work over considerable intervals of time. If the present paper has been able to draw attention and attach interest to some of the wide problems offered by the actinometry of the sky, it will have filled its purpose.

[1] Aldrich, L. B. The Smithsonian eclipse expedition of June 8, 1918 (Smithsonian Misc. coll., No. 9, 1919).

NOTE ON COMPARISONS BETWEEN PYRHELIOMETERS AND ON THE DIFFERENCE BETWEEN THE ÅNGSTRÖM STANDARD AND THE SMITHSONIAN STANDARD.

By Dr. ANDERS ÅNGSTRÖM.

[Dated: Meteorological Bureau, Stockholm, Sweden, October, 1919.]

The constant of the Ångström pyrheliometer No. 158, used by myself during expeditions to Algeria and California, was determined in 1912 from measurements of the width and resistance of the strips and found to be 13.58.[1] Using this value of the constant, the instrument was found to read 1.25 per cent lower than the standard instrument of the solar observatory at Upsala $\left[\frac{\text{Å } 158}{\text{Å. S.}}=0.9875\right]$, which we will indicate in the following by the Ångström Standard (Å. S.).[2] Shortly afterwards (in the summer 1912) the pyrheliometer No. 158 was compared by Dr. Abbot and myself with a newly standarized secondary pyrheliometer of the Smithsonian, (A. P. O. 9), and later by Dr. Abbot with the Smithsonian secondary standard itself (A. P. O. 8. bis.). The results of these comparisons were that No. 158 read 4.58 per cent ±0.15 lower than the Smithsonian standard (*S. I. S.*) $\left[\frac{\text{S. I. S.}}{\text{Å } 158}=1.0458\right]$. Consequently the differ-

[1] At the Solar Observatory at Upsala by Dr. Lindholm.
[2] As A. S. the pyrheliometer No. 70 has since 1906 been in permanent use.
[3] Ångström, Anders: Met. Zschft. H. 9/10, 1919.
[4] Kimball, H. H. See this REVIEW, pp. 769-793.

ence between the Å. S. and the S. I. S., was in 1912 3.27 per cent $\left[\frac{\text{S. I. S.}}{\text{Å. S.}}=1.0327\right]$.

Six years later—in the summer of 1919—I have now had the opportunity to make a new comparison between the readings of the Ångström pyrheliometer No. 158 and the Smithsonian scale at the observatory of Prof. Kimball of the U. S. Weather Bureau. A number of simultaneous readings were taken with No. 158 and the newly standardized Smithsonian Silver disk pyrheliometer No. 1. The conditions of the sky were not very favorable, very thin cirro-stratus causing irregular disturbances. No. 158 was found to read 4.9 ± 0.4 per cent lower than the Smithsonian (August 1919) $\left[\frac{\text{S. I. S.}}{\text{Å 158}}=1.049\right]$.

Immediately after my return to Sweden, No. 158 was compared by Dr. Lundblad with the Å. S. During the time of the observations the conditions of the sky were very favorable, the atmosphere being clear, the air very pure and calm weather prevailing. No. 158 was found to read 1.60 per cent ($\pm$ 0.1) lower than the Å. S. $\left[\frac{\text{Å 158}}{\text{Å. S.}}=0.984\right]$. Consequently the difference between the Å. S. and the S. I. S. is at present (in October 1919) found to be 3.23 per cent $\left[\frac{\text{S. I. S.}}{\text{Å. S.}}=1.0323\right]$.

There is an excellent agreement between this value and the one obtained 6 years ago, the difference falling much below the probable error (about $\pm$ 0.2 per cent). The result agrees further very well with results of comparisons by Marten at Potsdam, who found the difference between the Å. S. and the S. I. S. to be on the average 3.4 per cent.[3] From my comparisons it may be regarded as a safe conclusion, that neither the Ångström Standard nor the Smithsonian Standard has since 1912 been subjected to changes which practically need to be considered. The previous discussion consequently supports as well the opinions expressed by G. Granquist[4] in regard to the Ångstrom standard as those of C. G. Abbot[5] in regard to the Smithsonian one.

In a previous paper I have given reasons for assuming that 1.8 per cent of the difference between the pyrheliometer scales may be due to special features in the construction of the compensation pyrheliometer, whose readings consequently in general ought to be corrected by + 1.8 per cent. The remaining 1.5 per cent I am still inclined to believe to adhere to the Smithsonian scale, the measurements of Coblentz and of Royds having supported the value found by K. Ångstrom for the absorption power of soot and applied by him to the computed values of pyrheliometer constants.[6]

In applying given constants to pyrheliometric readings, it is, as in the case of all instruments, of great importance to make sure that the instrument itself is in unchanged condition, at least in its general and perceivable features. No one expects accurate results from the readings of a thermometer whose bulb has been broken, or a barometer whose mercury has been oxidized. In using the electrical-compensation pyrheliometer it is important to make sure that the strips are straight, uniformly black, and adhering to the supporting frame. An important source of error may arise from the fact that the measurements involve the use of a millammeter for reading the compensation current. Generally these millammeters are good and their temperature coefficient negligible—at least my own experience with the millammeters of Siemens and Halske and of Weston Electrical Instrument Company has been highly satisfactory. But it sometimes occurs that instruments even of the best make will show considerable errors, especially with change in temperature, and a control is therefore necessary. Especially the ammeters, which on expeditions are carried along with a pyrheliometer, need control through comparisons with other instruments or through new standardization at certain intervals. These precautions taken, the electrical compensation pyrheliometers seem, according to my experience, to be constant in their readings. Their disadvantage compared with the Smithsonian secondaries lies in their more delicate construction and their need of auxiliary instruments. Their chief advantage lies in the possibility of controlling the constant determination by measuring the width and resistance of the strips, which ought to be possible at every well-furnished physical laboratory; and, further, in the possibility of giving almost momentary values of radiation, which is especially important when one attempts to measure, for instance, the transmission of clouds, or tries to follow rapid variations in the radiation.

To Dr. Abbot, Prof. Kimball, Dr. Lindholm and Dr. Lundblad, my thanks are due for assistance in comparisons.

[3] W. Marten: Messunger der Sownerstrahlung in Potsdam in der Jahrcu 1909 bis 1912. (Veröff. des Königl. Preuss. Meteor. Inst., No. 267).

[4] Bericht über die erste Tagung der Strahlungs Kommision des internationalen Meteor. Komitees in Rapperswyl bei Zürich in September, 1912, Anhang IV, 1912.

[5] *Abbot and Aldrich:* Smithsonian Misc. Coll. Bd. 60, 1913.

[6] W. W. Coblentz: Bull. of Bureau of Standards, *9*, 193. Royds: Phys. Zeitschrift 1910, p. 316.

COMPARISON OF METHODS FOR COMPUTING DAILY MEAN TEMPERATURES: EFFECT OF DISCREPANCIES UPON INVESTIGATIONS OF CLIMATOLOGISTS AND BIOLOGISTS.

By F. Z. HARTZELL, Associate Entomologist.

(Author's abstract of Technical Bulletin No. 68, N. Y. Agricultural Experiment Station, Geneva, N. Y., June, 1919, 8°, 35 pp., 19 figs.)

[Dated: Vineyard Laboratory, Agricultural Experiment Station, Fredonia, N. Y., Nov. 8, 1919.]

The daily mean temperature is the thermal time unit in most general use among climatologists and ecological workers in botany and zoology; and, usually, this average is computed from maximum and minimum readings taken at some convenient hour. The true daily mean temperature is secured by mechanically integrating, with a planimeter, the corrected thermograph curve of the drum type of thermograph, or, in any case, by summing the average hourly temperatures, and dividing the result by 24 in every case. This mean is designated the thermograph average, while the approximate mean, computed from maximum and minimum readings, is known by the hour at which the observations were recorded; viz, the midnight, 12 p. m., 8 p. m., or 5 p. m. average.

It was found that the thermograph average seldom was the same as any of the corresponding approximate averages. The differences have been designated "discrepancies"; which are positive if the given average is greater than the thermograph average; negative, if less. The discrepancies for the various averages at Fredonia, N. Y. (Lake Erie Valley), for every day of 1916, were investigated by means of the statistical methods of Pearson.

In order to analyze the data, so as to determine the effect of the discrepancies on the mean annual temperature, the discrepancies for each series of averages were combined in frequency polygons, and the theoretical